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Wheat Yield and Weedness under Different Rate of Nitrogen Fertilization

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Abstract

In this study we tested yield and weediness in wheat cultivars Lazarica and Julija Mono grown under different regime of mineral nutrition. This investigation was conducted at the long term experiment on control variant (without fertilizers), second variant with nitrogen application (two sub variants with different rate of N) $2N_1$ (80 kg N ha^{-1}) and $2N_2$ (120 kg N ha^{-1}), third variant with NP fertilizer with two different rate of N application: $3N_1$ (80 kg N ha^{-1} + 100kg P ha^{-1}) and $3N_2$ (120 kg N ha^{-1} + 100kg P ha^{-1}) and fourth variant $4N_1$ (80 kg N ha^{-1} + 60kg P ha^{-1}) and $4N_2$ (120 kg N ha^{-1} + 60kg P ha^{-1}). Weediness varies in dependence of rate and variant of fertilization. The weed species *Consolida regalis* Gray, *Convolvulus arvensis* L., *Polygonum aviculare* L., *Cirsium arvense* L., *Agropyrum repens* L., *Polygonum convolvulus* L. was dominant on fertilized plots. The analyzed variability of grain yield depends of applied fertilizer variants. The lowest grain yield was found on control variant in both wheat cultivar Lazatica (1880kg ha^{-1}), Julija Mono (1740kg ha^{-1}) while the highest grain yield on variant $3N_2$ (120 kg N ha^{-1} + 100kg P ha^{-1}) Lazarica (3724kg ha^{-1} Julija Mono (4990kg ha^{-1}) and low weediness.

Key words: plant competitiveness, weediness, wheat, environment, grain yield, rate of fertilizer

Introduction

Wheat grain yield and yield components varied in dependence of crop nutrition, pest protection (Jolánkai et al., 2006) weediness and meteorological conditions (Márton, 2008). For achievement of high grain yield and quality it is necessary to optimize scientific farming measure like soil tillage (Sepp et al., 2009), optimal time and density of sowing (Petrović et al., 2008), level of water (Pawlonka &

Skrzyczyńska, 2004), fertilizer pesticide application (Füleky, 2008). In wheat and other cereal species yield losses under average weediness can reach about 30% (Mason et al., 2007). One of the most important elements of the crops protection is weed control. Time of sowing and density (Walter et al., 2002) of wheat is important for tillering, enough to suppress weed in spring season and reduce yield losses caused by late sowing, low temperature during winter and early spring time. Wheat density can influence the reduction of weed dry matter more than 60% (Lemerle et al., 1996) and reduction to weed structure (Korres & Froud-Williams, 2002). The application of herbicides do not influence the wheat density and wheat yield (Kristensen et al., 2008). Adequate wheat growing contributes to competitiveness with weed. Crop shading ability contributes to weed control by decreasing chemical application and environmental protection (Lemerle et al., 1996). Increase in wheat density and uniformity can help in suppression of weeds (Olsen et al., 2006). Wheat cultivars differ in competitiveness against weeds (Avramovic & Knežević, 2007) therefore the selection of cultivar is efficient preventive method of weed control (Hansen et al, 2008) and expression of economic traits. Wheat grain yield, as well as yield of other small grains, is in dependence of interaction of genotypes and environment (Oettler et al., 2006; Pepo, 2007) mineral elements availability (Kovačević et al., 2005) agro-ecological condition (Drezner et al., 2007) precipitation (Balogh et al., 2006) crop weediness (Fodor & Pálmai, 2008; Knežević et al., 2008). Also optimal application of fertilizer will increase vigour and competitiveness of cereal crop (Paunović et al., 2007). Grain yield and yield components and protein content increased with increasing NP fertilizer rates (Zečević et al., 2012). The increasing of nitrogen rate resulted in increasing of biomass formation both of cereal plants and weeds (Jolánkai et al., 2006; Knežević et al., 2007).

The aim of this paper is investigation of the effect of different rate of nitrogen fertilization to weed communities of winter winter wheat cultivars and variation of grain yield.

Materials and methods

The Lazarica and Julija Mono wheat cultivars grown under different regime of nitrogen nutrition were studied for weediness and grain yield. Cultivars were grown on long term experimental field of Center for Small Grains in Kragujevac on control variant (unfertilized), second variant with nitrogen application (two sub variants with different rate of N) $2N_1$ (80 kg P ha^{-1}) and $2N_2$ (120 kg N ha^{-1}), third variant with NP fertilizer with two different rate of N application: $3N_1$ (80-100 kg NP ha^{-1}) and $3N_2$ (120-100 kg NP ha^{-1}) and fourth variant $4N_1$ (80-60 kg NP ha^{-1}) and $4N_2$ (120-60 kg NP ha^{-1}). The analysis weed community and grain yield of wheat cultivars were conducted on four basic variants of soil fertilization and three replications. Unfertilized plots belonged to the smonitza type of soil in the process of degradation with pH of 6.03 to 6.10 in water and 4.76 to 4.84 in KC1. Floristic structure was estimated by method Braun-Blanquet (1964).

Results and discussion

The weed species in wheat cultivated under different regime of fertilization were identified. Different rates of nitrogen and phosphorus were influenced differences of weediness (tab. 1. and tab. 2). The lowest weediness registered on the plots of wheat crops where applied the highest rate of nitrogen. In each variant of applied fertilizer rates were registered between 7 and 11 weed species in both tested wheat cultivars Lazarica and Julija Mono. Mainly in all variants of nitrogen fertilization the weed species *Cirsium arvense* L*.*, *Consolida regalis* Gray, *Convolvulus arvensis* L*.*, *Polygonum aviculare* L. was dominant (tab.1 and tab 2).

The study of floristic structure determined that weeds community represents a fragment of *Consolida regalis-Polygonum aviculare* association having in it's composition 13 species. The weed species *Consolida regalis* Gray, *Convolvulus arvensis* L*.*, *Polygonum aviculare* L*.*, *Cirsium arvens* L*.*, *Polygonum convolvulus* L. were dominant on fertilized plots. These results are in agreement with previous results presented by Knezevic et al. (2008).

Different rate of nitrogen fertilization had positive effect on wheat crop density and no influence to the weeding level and botanical composition of the community. On control plots it was observed low density of crops. Fertilized plots characterized by presence of similar floristic composition of weed species in analyzed wheat cultivars, and registered less weed species as well as their different density. The increase of fertilizers rate had influence to the increase of the wheat plants tillering, the more development of the wheat plants and higher yields. Also, in these conditions the density of the weeds was reduced.

Other authors registered the most prevalent weed species *Capsella bursa-pastoris* L. and *Taraxacum officinale* F.H. Wigg (Harker et al. 2000). Density of weeds is dependent on weed species and soil properties. So, negative cross-correlation between the density of *Viola arvensis* Murray and clay content, while, density of *Lamium purpureum* L. was positively cross-correlated with the phosphorus content in the soil (Walter et al., 2002).

The interaction between cultivar and N supply had significant impact on yield. In this investigation we analyzed influence of weeds and fertilizer to variation of grain yield in wheat. The highest grain yield was found for wheat cultivars on the plots where the highest rates of fertilizer were applied. Cultivar Julija Mono expressed the highest grain yield (4990 kg ha^{-1}) and low weediness in fertilizers variant of $3N_2$ (120 kg N ha^{-1} + 100kg P ha^{-1}) what could be advantage for cultivation (tab. 3). On the same variant of fertilization $3N_2$ (120 kg N ha^{-1} + 100kg P ha^{-1}) other investigated wheat cultivar Lazarica achieved the highest yield (3724 kg ha^{-1}). Grain per square meter were positively correlated with grain yield and influenced by kernels per spikelet, a measure of fertility (Bennett et al., 2012).

Tab. 1.Weed species in wheat in control variant (no fertilized plots) 1N1, and in a variant with application of different NP fertilizer rates $2N_1$ (80kg N ha^{-1}), $3N_1$ (80-100kg NP ha^{-1}) $4N_1$ (80-100kg NP ha^{-1})

Врсте корова у пшеници у контролној варијанти (без ђубрених парцела) $1N_1$, и на варијанти са применом различитих доза азотног NP ђубрива $2N_1$ (80kg N ha^{-1}), $3N_1$ (80-100kg NP ha^{-1}) $4N_1$ (80-100kg NP ha^{-1})

	$1N_1$ (control)				$2N_1$ (80kg N ha^{-1})				$3N_1$ (80-100kg NP ha^{-1})				$4N_1$ (80-60 kg NP ha^{-1})			
	Lazarica		Julija Mono		Lazarica		Julija Mono		Lazarica		Julija Mono		Lazarica		Julija Mono	
Agropyrum repens L.	-	1.1	-	+.1	r	+.1	-	+.1	-	-	+.1	-	r	1.1	r	1.1
Consolida regalis Gray	+.1	1.1	+.1	1.1	+.1	1.1	+.1	-	+.1	1.1	-	+.1	+.1	1.1	+.1	1.2
Convolvulus arvensis L.	-	+.1	+.1	-	+.1	-	+.1	1.1	+.1	-	-	+.1	+.1	1.1	+.1	1.1
Linaria vulgaris Mill.	+.1	-	r	1.1	-	-	+.1	-	-	-	+.1	-	-.1	1.2	-.1	1.1
Sorghum halepense L.	-	-	-	-	r	+.1	r	+.1	-	-	-	-	r	-	-	+.1
Viola arvensis Murray	r	-	-	r	-	+.1	-	+.1	r	+.1		+.1	-	r	r	1.1
Polygonum aviculare L.	+.1	1.1	r	1.1	r	+.1	+.1	1.1	-	+.1	+.1	-	+.1	1.1	+.1	1.1
Polygonum convolvulus L.	-	+.1	-	+.1	-	+.1	-	+.1	r	+.1	r	+.1	+.1	1.1	+.1	1.1
Chenopodium album L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Veronica opaca Fries	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r
Cirsium arvense L.	+.1	1.1	+.1	1.1	+.1	1.1	-	+.1	+.1	1.1	+.1	1.1	r	1.2	r	2.2
Rubus caesius L.	1.1	-	-	-	-	-	-	-	-	+.1	-	+.1	-	-	-	-
Mercurialis	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total no. of species:	11		9		8		9		7		9		9		10	

Tab. 2. Weed species in wheat on controls variant (no fertilized plots) $1N_2$, and on variant with application of different NP fertilizer rates $2N_2$ (120 kg N ha^{-1}) $3N_2$ (120-100 kg NP ha^{-1}) $4N_2$ (120-60 kg NP ha^{-1})

Врсте корова у пшеници у контролној варијанти (без ђубрених парцела) $1N_2$, и на варијанти са применом различитих доза азотног NP ђубрива $2N_1$ (80kg N ha-1), $3N_1$ (80-100kg NP ha-1) $4N_1$ (80-100kg NP ha -1)

	$1N_2$ (control)				$2N_2$ (120kg N ha^{-1})				$3N_2$ (120-100kg NP ha^{-1})				$4N_2$ (120-60 kg NP ha^{-1})			
	Lazarica		Julija Mono		Lazarica		Julija Mono		Lazarica		Julija Mono		Lazarica		Julija Mono	
Agropyrum repens L.	+.1	1.1	+.1	1.1	r	+.1	r	+.1	-	-	+.1	-	r	1.1	+.1	1.1
Consolida regalis Gray	+.1	-	-	-	+.1	1.1	-	1.1	+.1	-	-	+.1	+.1	1.1	+.1	1.1
Convolvulus arvensis L.	+.1	-	+.1	1.1	-	+.1	+.1	1.1	-	+.1	+.1	-	+.1	1.1	+.1	1.1
Linaria vulgaris Mill.	-	-	-	+.1	+.1	1.1	r	-	-	-	-	-	-	-	-	-
Sorghum halepense L.	-	-	-	-	r	-	-	r	-.1	+.1	-.1	+.1	-.1	+.1	-.1	+.1
Viola arvensis Murray	-	-	-	-	r	+.1	-	r	-.1	+.1	r	+.1	+.1	1.1	+.1	1.1
Polygonum aviculare L.	+.1		+.1	-	+.1	1.1	r	1.1	+.1	-	-	+.1	+.1	1.1	+.1	1.1
Polygonum convolvulus L.	-	+.1	+.1	-	+1	-	-	+.1	-.1	+.1	-.1	+.1	+.1	1.1	+.1	1.1
Chenopodium album L.	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-
Veronica opaca Fries	r	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-
Cirsium arvense L.	+.1	1.1	+.1	1.1	-	+.1	+.1	1.1	+.1	1.1	+.1	1.1	+.1	1.2	r	1.1
Rubus caesius L.	-	-	-	+.1	-	-	-	-	+.1	1.1	+.1	1.1	-	r	-	-
Mercurialis	-	-	-	-	r	-	-	r	-	-	-	-	-	-	-	-
Total no. of species:	7		7		11		10		8		9		10		9	

The least grain yield was found on control variant for both of analyzed wheat cultivars Lazarica (1880kg ha^{-1}) and Julija Mono (1740kg ha^{-1}) tab. 3. Cultivar Julija Mono had higher grain yield (2586kg ha^{-1}) on plot fertilized by 80kg N ha^{-1} (variant 2N$_1$) than cultivar Lazarica (2420kg ha^{-1}). Also on variant 2N$_2$ (120kg N ha^{-1}) cultivar Julija Mono had higher grain yield (2680kg ha^{-1}) than cultivar Lazarica (2470kg ha^{-1}).

Tab. 3. Average yield of grain (kg ha^{-1}) of examined wheat cultivars under the different variants of fertilization
Просјечан принос зрна (kg ha^{-1}) испитиваних пшеничних сорти под различитим варијантама ђубрења

Cultivar / *Сорта*	Lazarica		Julija Mono	
Variants / *Варијанте*	*Plot Парцела*	Hectare	*Plot Парцела*	Hectare
Control 1	940	1880	890	1780
Control 2	955	1910	870	1740
2N$_1$ (80 kg N ha^{-1})	1210	2420	1293	2586
2N$_2$ (120 kg N ha^{-1})	1235	2470	1340	2680
3N$_1$ (80 kg N ha^{-1} + 100kg P ha^{-1})	1796	3592	2192	4384
3N$_2$ (120 kg N ha^{-1} + 100kg P ha^{-1})	1862	3724	2495	4990
4N$_1$ (80 kg N ha^{-1} + 60kg P ha^{-1})	1565	3130	1996	3992
4N$_2$ (120 kg N ha^{-1} + 60kg P ha^{-1}).	1645	3290	2178	4356

In general, increasing rates of NPK fertilization caused only a significant increase in the yields. Similar results obtained in the crop rotation at lower rates 150–300 kg NPK ha^{-1} (Füleky, 2008). Increasing assimilate allocation to the reproductive primordia indirectly increase total crop photosynthesis and intensive development growth of vegetative reproductive organs in wheat. However, total photosynthesis has increased as a result of an increase in leaf area, daily duration of photosynthesis or leaf area duration (Richards, 2000). Even small increases in the rate of net photosynthesis can translate into large increases in biomass and hence yield, since carbon assimilation is integrated over the entire growing season and crop canopy.

Conclusion

The results of investigation showed differences of weediness in wheat cultivars and specific interaction genotype/nitrogen rate. The increasing in fertilizer rate affected grain yield as well abundance of weed species. The higher rates of nitrogen fertilizer rate have effect to efficient competition of wheat plants and composition of weed species which leads to increase of grain yield. The highest grain yield in wheat Julija Mono (4990 kg ha^{-1}) was found in variant 3N$_2$ (120 kg N ha^{-1} + 100kg P ha^{-1}). Also tested cultivar Lazarica achieved the highest higher yield (3724 kg ha^{-1}). Breeding of wheat cultivars for improving grain yield require complex work in direction to improving several types of abiotic stress as well tolerance to drought, high temperatures, high irradiance, and nutrient toxicities or deficiencies. A strategy is then described where a specific environment is targeted and appropriate germplasm adapted to the chosen environment, based on extensive definition of the morpho-physiological and molecular mechanisms of tolerance of the parents. In wheat grown under different application of nitrogen fertilizer identified different weed species while prevail weed species were *Cirsium arvense* L., *Consolida regalis* Gray, *Convolvulus arvensisI* L., *Polygonum aviculare* L. For weed management strategy in wheat should be optimize technological growing measures. One of the strategies to reduce weediness based on increasing of sowing density in conventional agriculture and it is a way to reduce herbicide application levels and further this strategy may have other positive influence to environment including fuel consumption and carbon dioxide (CO_2) production.

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Принос пшенице и присуство корова при примени различитих доза азотног ђубрива

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Сажетак

У овом раду је представљено изучавање приноса зрна и појава коровских врста у усевима две сорте озиме пшенице (Лазарица и Јулија Моно), гајених у условима различитог режима минералне исхране. Изучавања су обављена на дугогодишњем огледу са четири варијанте ђубрења са по две варијанте са различитом дозом примене азотног ђубрења: контролна варијанта (без ђубрења), друга варијанта примене азота са две подваријанте са различитом дозом азота $2N_1$ (80 kg N ha^{-1}) и $2N_2$ (120 kg N ha^{-1}), трећа варијанта са две подваријанте $3N_1$ (80 kg N ha^{-1} + 100kg P ha^{-1}) и $3N_2$ (120 kg N ha^{-1} + 100kg P ha^{-1}) и четврта варијанта са две подваријанте $4N_1$ (80 kg N ha^{-1} + 60kg P ha^{-1}) and $4N_2$ (120 kg N ha^{-1} + 60kg P ha^{-1}). Оцена је урађена у три понављања на свим варијантама ђубрења. Метода Braun-Blanquet (1964) је коришћена за оцену флористичког састава у усевима две сорте пшенице. Регистровано је 13 различитих коровских врста са различитом бројношћу, која је показала одређену зависност са примењеним дозама азотног ђубрива. На нећубреним парцелама је установљено веће присуство корова. Повећавање дозе азотног ђубрива на парцелама је утицало на већу густину усева пшенице и смањен интензитет коровских врста. Коровске врсте *Consolida regalis* Gray, *Convolvulus arvensis* L., *Polygonum aviculare* L., *Cirsium arvense* L., *Agropyrum repens* L. и *Polygonum convolvulus* L. су биле доминантне на ђубреним парцелицама. Изучаван је принос зрна пшенице и установљено је варирање зависно од исхране. На парцелама без додавања азота принос зрна је био најнижи код сорте Лазарица (1880kg ha^{-1}), и Јулија Моно (1740kg ha^{-1}). Највећи приноси зрна су добијени на парцелама са варијантом ђубрења $3N_2$ (120 kg N ha^{-1} + 100kg P ha^{-1}) и то код Лазарице (3724kg ha^{-1}) и Јулије Моно (4990kg ha^{-1}) а на овој варијанти је установљена и најмања закоровљеност. Ово указује да оптимизација примене ђубрења доприноси повећању густине усева пшенице, већој компетитивности са коровским врстама, што утиче на мање присуство корова и смањену потребу употребе хербицида, чиме се значајно доприноси смањењу трошкова енергије и очувању животне средине.

Кључне речи: компетитивност, закоровљеност, пшеница, спољашња средина, принос зрна, доза ђубрења

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